No. 148 October 2009

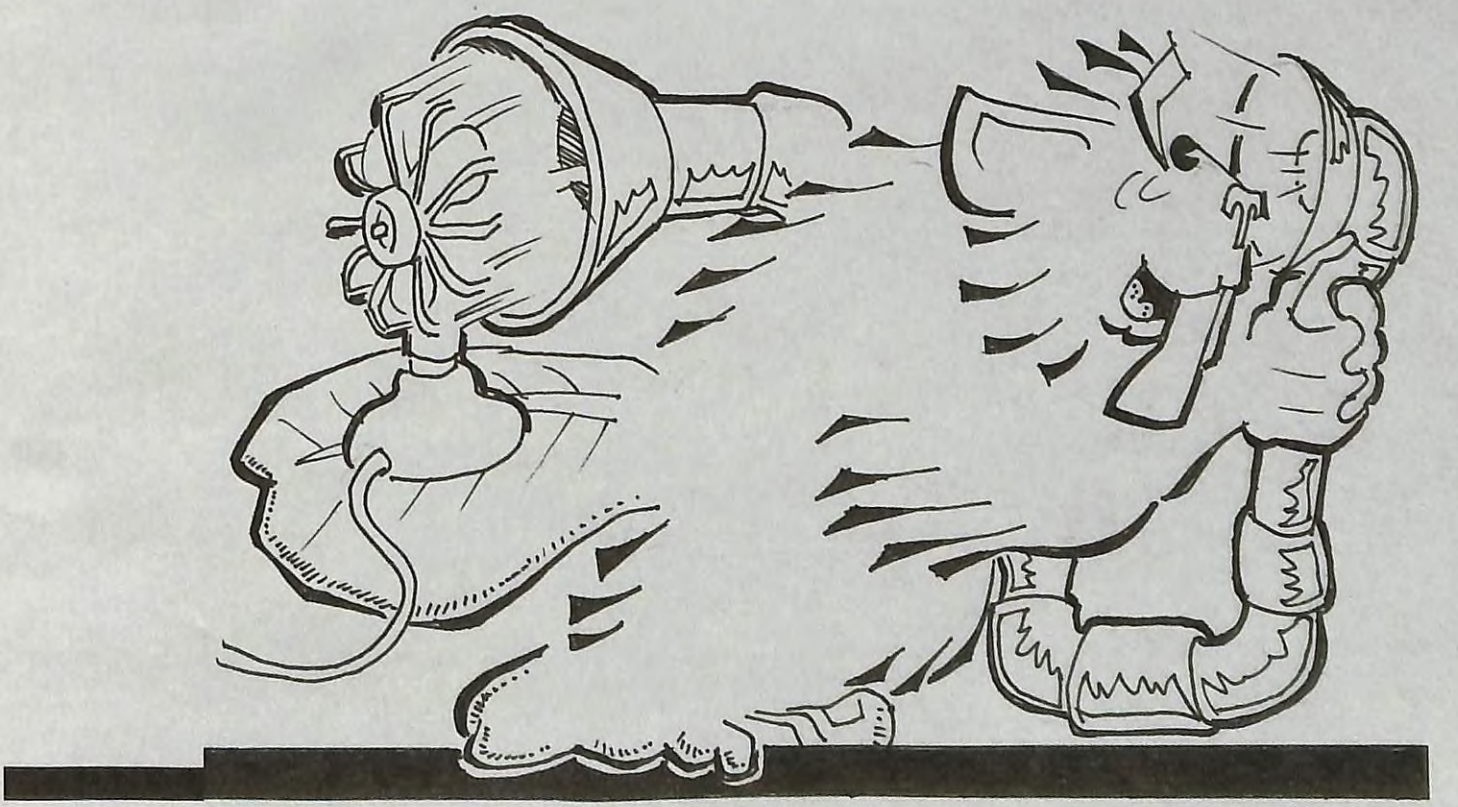
solplan review

the independent journal of energy conservation, building science & construction practice

Inside . . .

Basics of Airflow 3
Equivalent lengths for typical sheet metal fittings.....5
What Is A Vapour Barrier?.....7
Letters to the Editor 8
Demonstration Projects: Learning by Experience: The Seabird Island Demonstration Project.....9
Technical Research Committee News.....12
Energy Answers 14
House Fires: Running out of Time.....16
Hybrid hydrogen / natural gas high-efficiency furnace system 18

Basics of Airflow



From The Editor . . .

The importance of doing it right does not always get the proper attention it deserves. It is human nature to want to jump to conclusions and get results quickly. Similarly, authorities often use regulations as a policy instrument to drive change. Code and standard changes often fall into this category. If not carefully thought out, prematurely implemented regulations can result in tremendous confusion, and worse outcomes than no action.

Sometimes, the drive to move forward is done at a breakneck pace with the best of intentions. There are times when changes simply need to be introduced by regulation, since the fear of the unknown is a strong force against change. Human nature is to procrastinate, and stick to the comfort of what is known rather than move into what may be considered as the unknown.

Regulatory change needs to be done in a way that is meaningful and achievable by those impacted. After all, there is not much point in establishing standards that are not going to be achieved.

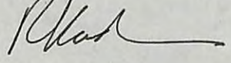
I've been observing recent building code changes in the City on Vancouver. They have been very aggressive in moving the green agenda, aiming to be leaders of the pack. I have no problems with that. Indeed, I think this is definitely the direction our codes need to be moving. We need to come to grips with the significant, meaningful changes that need to question the way we do business.

When the City introduced their new standards, nothing meaningful was done to support the industry, including sub-trades, to help them meet the new standards. Nor were the City's own staff fully appraised or empowered to enforce the new standards. Sadly, the City even turned a deaf ear to industry groups that offered to help with initiatives to inform trades and city personnel on means to effectively comply with the new regulations. As a result dubious details and practices are being used that go counter to the intent of the new regulations. It will only entrench public perceptions that bureaucracy doesn't know anything about real life, and engender resentment about 'green' initiatives.

One example I've observed revolves around a new requirement that every house must have a heat recovery ventilator installed. The intent of the regulation is laudable. However, if an HRV is not installed correctly, it will neither deliver the desired air change, nor be operated by the owner, especially if a lousy installation means a noisy installation. It adds cost to the homeowner, and although it generates a market for equipment to make manufacturers happy, there is no certainty that the equipment will deliver the fresh air.

Another is that the City became the first jurisdiction in North America to require energy labelling of all new homes before issuing an occupancy permit on completion of construction. Great idea, but they didn't think it through properly, and that it would require a few days for third parties to do the final file audit and certification. They still expect that the complete Energuide process be carried out, right through to the issuance of the certificate, but they are only collecting a copy of the energy advisor's assessment and house report. Expecting someone to continue with a certification process when it is not going to be checked is the same thing as asking a driver to voluntarily go to the police station to report jumping the red light or speeding through a speed zone. It's why we have inspectors and other third parties to verify or at least audit activity.

The way that the City of Vancouver has implemented their aggressive green building code changes is a concern and should be a lesson for others. Vancouver jumped into action ahead of the capacity of the industry to deliver, and what is worse, there is no evidence that there is a willingness to ensure that the changes are being implemented correctly.



Richard Kadulski,
Editor

solplan review
the independent journal of energy conservation, building science & construction practice

Editor-Publisher: Richard Kadulski
Illustrations: Terry Lyster
Contributors: Judith Hunt, David Hill, Ken Cooper, Rob Dumont, John Burrows, Janet Ansell
ISSN: 0828-6574
Date of Issue: October 2009
SOLPLAN REVIEW is published 6 times per year by:
the drawing-room graphic services ltd.
PO Box 86627, North Vancouver, BC V7L 4L2
Tel: 604-689-1841 Fax: 604-689-1841
e-mail: solplan@shaw.ca
Street address:
#204 - 1037 West Broadway
Vancouver, BC V6H 1E3

Publications Mail Agreement No. 40013363
Postage paid in Vancouver, BC.
Return undeliverable Canadian addresses to
PO Box 86627, North Vancouver, BC V7L 4L2
COPYRIGHT 2008 by The Drawing-Room Graphic Services Ltd. All rights reserved.
Reproduction without written permission of the publisher is strictly forbidden. Transgressors who don't take heed note: the dust on the project will be more than an early hoar frost.
A license for photocopying or other reprographic copying can be also be obtained from Access Copyright (Canadian Copyright Licensing Agency, 1 Yonge St., Suite 800, Toronto, ON M5E 1E5).
SUBSCRIPTIONS: In Canada 1 year $52.50 (incl GST) (NB, NS, NF $56.50 includes HST); 2 years $93.97 (incl GST) (NB, NS, NF $101.13 includes HST). USA and other foreign payable in US $ 1 year $57.00, 2 years $103.50.

CHANGE OF ADDRESS: include a mailing label or copy all information off label for faster, accurate processing.
CONTRIBUTIONS: Unsolicited contributions and manuscripts welcome. Include self-addressed pre-stamped mailer if return requested. Publisher not responsible for loss or damage of same.
While every effort is made to provide accurate and complete information, we do not warrant or guarantee the accuracy and completeness of such information.
ADVERTISING POLICY: Publisher's discretion in the acceptance of any advertisement. No endorsement is stated or implied by the publisher.
PRINTED IN CANADA
GST Registration: R105208805
SOLPLAN is a registered trademark of the Drawing-Room Graphic Services Ltd.

Basics of Airflow

Forced warm air heating is the most common heating system in use in Canada. Air handling systems are an integral part of homes. We rely on moving air to heat, cool and ventilate our homes, and have done so for a long time. In the past generation, dedicated distributed ventilation systems have become more common.

The design of forced warm air heating systems has relied on a tradition that evolved slowly by trial and error, and has been reasonably effective. In recent years there have been many technical changes to equipment and systems, but it is evident that industry training and expertise in the field has not kept pace. That is why TECA (Thermal Environmental Comfort Association) developed a new course – The Basics of Air.

Why a course?

The course was developed because it was recognized that the basic properties of air and how to move it effectively and efficiently are not well understood by the industry. Early gravity air heating systems provided heat distribution without fans but with effective duct layouts. For the past half century, cheap energy has meant we have tolerated less efficient equipment that relied on inefficient fans to overcome bad duct design.

The trend today is greater use of air conditioning and more energy efficient furnaces that have larger blower motors to move the greater airflows than older equipment. Most users do not appreciate that today's high efficiency gas furnaces circulate twice the amount of air as older furnaces. Similarly, for the same output, high efficiency heat pumps circulate three times more air than older furnaces. However, the higher volumes of air for proper circulation of the new efficient equipment is not always being accommodated with proper duct design. This especially has an impact on retrofits of high efficiency equipment into older duct systems.

The challenges have become more complex today for system designers and installers because of the changes in house design. Today there is less room for mechanical rooms and equipment, less tolerance for ceiling drops to accommodate ducts and structural layouts that include flush beams with limited possibility to run ducts through the framing members. This means that more air is being moved through ducts that may be too small, resulting in noisier systems.

The Basics of Air course presents knowledge that may have been lost since the demise of gravity air heating systems. It explains how to efficiently and quietly move air volumes required by modern equipment.

The course explains terms like duct velocity, airflow rate, duct aspect ratio and air density. The course and documentation uses plain language and scaled-down hand's-on exercises to help installers understand the principles. It was designed to provide the HVAC designer and installer with convincing reasons to size ducts adequately and to help sell both the consumer and related construction industry members on the higher cost of installing proper fittings and the reason why it is critical to make adequate space available for their installation. Although this may seem self-serving for the mechanical trades, it is a fact that too many decisions are made simply based on the initial cost and not on the quality of performance to be expected.

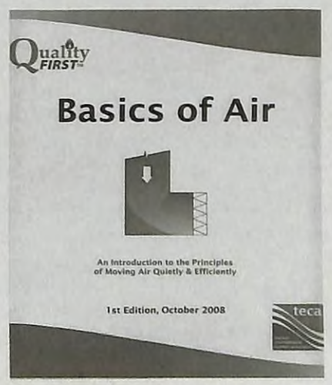
Basic concepts covered

Flow

Velocity: the speed or rate at which air moves.

Flow rate: the volume of air moving in a duct. Flow rate is used to describe how much air moves through a duct. Typically the unit of measure is cubic feet per minute (cfm). In metric terms, it is litres per second, although the residential mechanical industry works almost exclusively in imperial units.

The volume of air moving in a duct is directly proportional to the velocity of the air moving through the duct. To double the volume of air flowing through a duct you either need to double the duct cross-sectional area or double the velocity of the air.


Quality FIRST
Basics of Air
An Introduction to the Principles of Moving Air Quietly & Efficiently
1st Edition, October 2008
teca

Pressure

Pressure is the force exerted on the air to move it through the duct. The pressures in air ducts are usually quite small. Pressure is measured as a difference between a reference point (e.g. atmospheric pressure) and that in the duct. When pressure is applied to air in a duct to move it (e.g. when a fan is turned on), the duct pressure will be the difference between the atmospheric pressure and that in the duct.

The pressure in the duct system is referred to as the static pressure. The greater the static pressure, the faster the air will flow through the ducts. Systems that operate at high static pressures use more energy to move the air, and may not be as efficient overall.

Large pressure losses are created by duct fittings that change the direction of the airflow. When airflow direction changes, eddy currents are created in the ductwork due to sharp edges or tight radiuses, and airflow is disturbed and flows through different portions of the fitting at different velocities. Fittings that minimize abrupt airflow direction changes are most efficient.

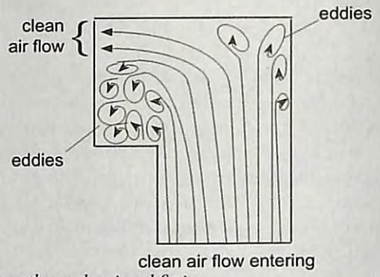
The type of equipment used governs system design pressure drops. All furnaces are capable of total design pressure drops through the duct system of up to 0.90" water gauge (225 Pascals). An air conditioning coil or filter could each add a pressure drop of up to 0.3", leaving that much less for the duct system.

Duct Sizing

Different volumes of air are required in different portions of a house, depending on heating, cooling or ventilation loads. Proper design requires knowing the loads in each room, so that the system can be sized correctly.

When sizing duct systems to control noise and pressure loses include, it is important to recognize that the slower the air moves in the duct:

- Less friction is created
- Less noise
- Larger duct size is needed
- Higher cost for larger duct
- More difficult to incorporate in a structure
- Smaller fan is needed
- Less electrical consumption



Airflow through mitred fitting

Friction losses

When air moves through a duct, the boundary layer of air is subject to friction at the duct surface. Friction losses increase proportionally to the velocity pressure in the duct. As duct size decreases, the velocity of air increases for a given volume of air, and when velocity increases, so do the friction losses.

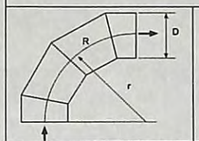
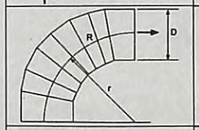
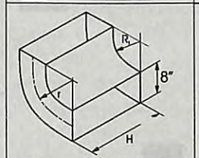
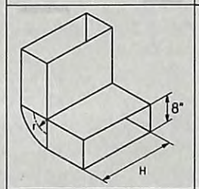
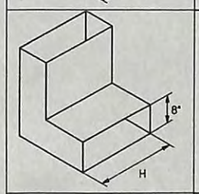
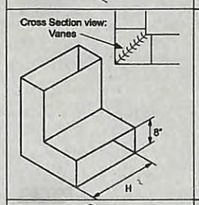
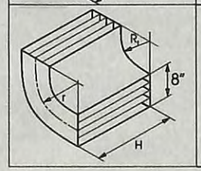
For example, if the duct area is decreased by half and the velocity of air is doubled to deliver the same volume of air, the velocity pressure (and static pressure) is four times greater. This means more energy is required for the fans, and there will be more noise in the system. That is why the smaller the duct size that is chosen for any given volume of air, the more critical is it to choose duct fittings that are efficient.

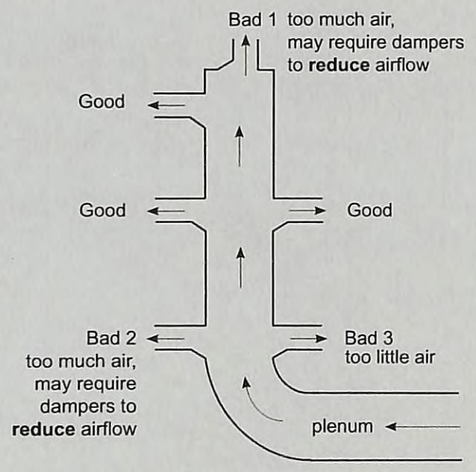
System design

Careful attention to duct design and especially to fittings is required to reduce the inefficiencies introduced by turbulence and pressure loses. Unless friction and pressure losses are calculated correctly and accounted for in the system design, it will not be able to efficiently deliver the air where it is wanted.

Location of takeoffs and their size requires careful thought, as conditions inside a duct vary. Some areas have higher pressures than others, so will influence how the air flows through. In general, takeoffs should be placed in areas of high static pressure, which will help airflow. The shape of the fitting should also be considered, so that it aids the movement of air. Too many sheet metal fittings seen today are crude sheet metal assemblies that do not aid the proper movement of air.

Equivalent lengths for typical sheet metal fittings

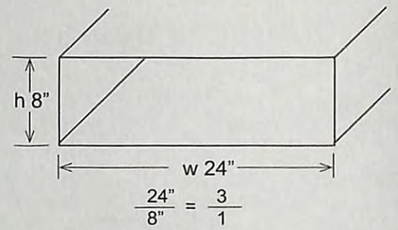
Elbow Fitting		Size	Velocity			
			500 fpm		1000 cfm	
			Equivalent length	CFM	Equivalent length	CFM
	4 piece elbow	8" diameter	14	174	16	348
	8 piece elbow	8" diameter	3	174	3	348
	Smooth heel & throat, no vanes	8"x12"	6	333	6	667
	Smooth heel, square throat, no vanes	8"x12"	35	333	40	667
	Mitred, sharp heel & throat, no vanes	8"x12"	37	333	43	667
	Mitred, with vanes	8"x12"	11	333	13	667
	Smooth heel & throat, 3 splitter vanes	8"x12"	1	333	1	667



Location of branch take-offs in a supply plenum (plan view)

The Basics of Air course, perhaps more correctly titled the Fundamentals of Moving Air Quietly and Efficiently, is TECA's newest course offering. The twelve-hour course is also a component course of the Certified Heating Technician's 2nd year Air Systems Program.

Information: www.teca.ca



Duct with 1 to 3 aspect ratio

Aspect ratio of a rectangular duct is the width divided by the height. A square duct has an aspect ratio of 1, while an 8" x 24" duct has a ratio of 3. Ducts with high aspect ratio are less efficient for any given area because of the ratio of the duct surface area to the volume, and consequently greater surface friction to impede airflow. Thus, shallow but wide ducts, although they may look attractive from the point of view of minimizing ceiling drops, will not be an efficient way to deliver air.

Equivalent length is a term to refer to the length of a straight duct that would have the same pressure loss as a fitting. This is the most common method for calculating duct pressure losses. Tables are available that list the equivalent lengths of different sizes and configurations of fittings.☼

energy efficient, sustainable, and healthy buildings
design & consulting services
R-2000 File Management
HOT-2000 Analysis
SuperE™ House Program Design Professional

Richard Kadulski Architect

#204 - 1037 West Broadway
Vancouver, B.C. V6H 1E3
Tel: (604) 689-1841
Fax: (604) 689-1841
e-mail: kadulski@direct.ca

Solplan Review Back issues

A limited number of back issues are available, at a special price of $5.75 each (plus 6% GST).

Bundle special: a random selection of back issues (minimum 22 copies) are available for only $65.00 (plus 6% GST)

Solplan Review
Box 86627
North Vancouver, BC V7L 4L2
e-mail: solplan@shaw.ca

What Is A Vapour Barrier?

It is important to control condensation in building assemblies that could happen as a result of excessive vapour diffusion through the assemblies. Vapour barriers restrict the diffusion of water vapour through a construction assembly. The intent is to avoid the accumulation of moisture on cold surfaces, where condensation can contribute to moisture induced deterioration. While codes refer to them as vapour 'barriers,' the more appropriate terminology should be vapour diffusion retarders.

Condensation, if uncontrolled, can lead to a build-up of moisture and subsequent mould growth. This could potentially affect the health of occupants, especially if airflow or decay occurs resulting in damage to the building itself.

A very small amount of water vapour movement through most assemblies is not a problem. In some conditions, if an assembly has a minute amount of permeability, it will avoid problems, rather than create them.

The National Building Code of Canada defines a vapour barrier as a material with a vapour permeability not more than 60 ng/Pa-s-m^2. In practical terms, vapour barriers are interpreted as meaning 6-mil polyethylene. However, many products have a low vapour permeance and could be used to control vapour diffusion.

The permeability of many materials is published in technical literature, in CCMC product listings, or handbooks. For example, the permeability of 2-3" of closed cell SPF or 2" of softwood both meets the Part 9 NBCC definitions of vapour barrier (i.e., a permeability of less than 60 ng/Pa-s-m^2).

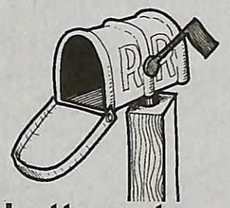
Unfortunately, there is often confusion between the vapour barrier and the air barrier. This occurs especially because materials that are used as vapour barriers often are also used as an air barrier, which is much more important. However, air barriers do not need to resist vapour diffusion, and can be different materials than vapour barriers.

The National Building Code distinguishes between air barriers and vapour barriers. Proposed changes this code cycle should further help clarify the distinction. The important point being that although a 6-mil polyethylene sheet, caulked and sealed can serve both functions, it is not the only way to build air and vapour barrier systems. There are other ways that may even provide superior overall building performance.

Regrettably code users often confuse the two with the result that builders and designers sometimes have difficulty using alternate systems that separate the two. It is air barriers that must be continuous and air tight, but vapour barriers do not need to be airtight. Vapour barriers need to substantially cover the entire exterior surface, but need not be continuous – discontinuities in the vapour barrier will not affect overall performance of an airtight building envelope. ☼

Vapour Permeability of Materials

Material	Vapour permeability ng/(Pa-s-m²)	
6 mil polyethylene	2 – 6	
1" foil faced polyisocyanurate	4	
Wood stud (spruce)	5	
11 mm oriented strandboard	44	OSB permeability varies with relative humidity – at higher humidities, permeability increases but not as dramatically as in plywood
Vapour barrier primer paint	26 – 39	
1" extruded polystyrene	23-92	Permeability decreases with increased thickness
3/8 – 5/8" plywood	40 – 57	Plywood permeability varies with relative humidity – at higher humidities, permeability increases
Closed-cell (2-pound) polyurethane spray foam insulation (2" thickness)	60	Permeability decreases with increased thickness
Reinforced concrete	23	
½" Gypsum board, painted 1 coat primer & 2 coats latex paint	180	
MemBrain™ (2-mil-thick polyamide-6 (nylon-6)	4-60	Not appropriate as vapour barrier if interior relative humidity is greater than 60% - see CCMC 13278-R
Open-cell (½ pound) spray foam insulation (1" thickness)	940 - 1218	
Stucco	75-240	Traditional cementitious stucco
½" Gypsum board (unfinished)	2600	
Building Code defines a vapour barrier as a material with a vapour permeability of less than 60 ng/Pa-s-m^2		



Letters to the Editor

Re: Green Labelling: What's in a Label?

I am disappointed that you did not mention Built-Green™ in the article (Solplan Review 147). You seem to be promoting the LEED® Canada for Homes Rating System at the expense of an established market-based initiative that has an established track record with well over 11,000 homes registered. Built-Green does have a significant impact on the building environment.

Chris Erb,
Nanaimo, BC

We did not intend to slight any green building program. I find it very heartening to see the impact the Built-Green has had in the marketplace in Alberta and BC. However, to be fair it is only one of several Canadian programs that were not specifically addressed – including Energy Star Homes, Novoclimat, and Power Smart New Homes, to name only three.

The proliferation of labels is disturbing, but a reality of the marketplace. At the end of the day, what matters is what real impact these programs will have on improving and making the housing stock more sustainable.

Labelling programs represent a challenge. They really only provide guidance for the directions that designers and builders should follow to make their product more sustainable, and have a lower impact on the environment. Their value is that they offer third party credibility to back up claims.

We meant to highlight the analysis that CHBA has prepared to compare the new LEED Canada for Homes Rating system with the established R-2000 standard, which can be considered to be the grandfather of most energy-efficiency and green building systems. It was meant to also point out the significant shortcoming of the LEED-H program which is the low weighting given to energy efficiency.

We wanted to highlight that building code regulated minimum energy efficiency requirements in a number of Canadian jurisdictions already exceed what is the acceptable minimum for LEED. For a standard that aims to set the bar for sustainability, not to set the minimum higher than minimum code requirements does not send the right message.

Unfortunately, downplaying energy efficiency reinforces the image that many, especially designers, have that energy efficiency is difficult and in the end is not really that big an issue. Consequently, too much effort is devoted to the provenance of materials and their embodied energy, even though overall the embodied energy is a much smaller part of the sustainability equation

The strength of Built-Green is that it has created a means of getting mainstream builders involved, and an achievable means of improving their product. Ed.

Re: Energy Answers, Solplan Review 147

I have been a great fan of Solplan Review for many years.

The "Energy Answers" column is timely as most of your reviews are.

What California has done is admirable but one wonders if over regulating causes as much or more harm in other ways. Remember, California is bankrupt. I think in our zeal to do the right thing we need to step back now and again to consider all the implications of our actions.

Bart Blainey
Consultant
Victoria, BC

Thanks for the comments. Over-regulation is always a concern. However, much as we may not want any, regulation is a part of organized society. At times, regulation needs to be introduced to protect us from ourselves.

The example of energy consumption regulations in California points out the long-term impact that measured regulation can have. Remember that some of the energy regulations stem from concerns other than energy efficiency or even environmental concerns. Many of the regulations are driven by fundamental health concerns – to cut pollution levels that affect the health of the population in southern California.

That California is bankrupt is more a result of lack of controls and regulations in some areas rather than too much. Deregulation, lack of fiscal controls and a dysfunctional political system are to blame there. Ed.

Demonstration Projects: Learning by Experience:

The Seabird Island Demonstration Project

Demonstration projects are useful tools to showcase and try out new technologies. They also provide a vehicle for research and education. However, for them to be more than simple marketing exercises, it is important that the lessons learned be described and made available to the industry.

Over the past generation, there have been many projects that have incorporated new technologies and alternate energy ideas with more or less success, but we don't always get the results of how well they performed.

In our world of quick sound bites a lot of coverage is given when a project is built, but little attention is given to how it performs over time, especially when the performance was not up to expectations. There is little or no follow-up by anyone except perhaps the few directly involved. Yet it is the follow-up that is important to gain new insights on what works and what doesn't.

A house is a complex system, which introduces new challenges when attempts are made to try out or demonstrate new technologies. Too often, where new ideas are being tried, too many items are introduced at the same time and inadequate monitoring and reporting is done. When a project is completed and monitored, it is important to pass on the findings.

With the recent reawakening of interest in renewable energy and sustainable development approaches, many ideas are being tried out. Some ideas being trotted out as new were tried a generation ago – in the mid 1970s as a result of the first oil shock. Some worked, others didn't.

Some ideas that worked did find their way into the mainstream. The R-2000 program is one successful example of technology transfer that helped industry incorporate advanced technologies. Although the number of certified R-2000 houses may not be large, the program activity has had a beneficial effect on all sectors of the homebuilding industry.

Ideas that were tried out may have received some monitoring, but with the resolution of the effects of the oil shock in the late 1970s and changes in political policies meant the abandonment of energy projects in favour of the status quo. The result is that a lot of valuable information got sidetracked, lost, or stuffed into boxes and sits to be rediscovered by some adventurous soul ready to data-mine documents the old fashioned way. (Whatever information is available is in research/monitoring reports that are on paper, done in the pre-PC computer and pre-Internet era).

The Seabird Island demonstration project near Agassiz, BC is an example of a recent project with good intentions that could have benefited from a more careful review of past experiences. It was designed to promote and demonstrate sustainable approaches for the design and construction of First Nations housing. It has seven housing units in four buildings – one duplex, one triplex, and three single-detached units (one a conventionally constructed house for comparison).

The Seabird Island project incorporated many features to reduce energy consumption and environmental impact while promoting sustainable resource use and healthy indoor environments. Some are interesting, but a careful analysis would have identified some as being dubious and could have been screened out at the design stage.

- Solar orientation was the driving force behind the design of the site, the form of the houses and their placement on the site.
- Climatic factors also influenced the form and details of the buildings. Steel roofs with large overhangs were provided to protect the rain-screened exterior walls from the high rainfall experienced in the coastal climate of British Columbia.
- Each unit has a high-efficiency, condensing, natural gas water heater supplying space heating through a combination of forced-air and radiant-floor heating, as well as supplying the domestic hot water.
- Solariums were designed to provide solar preheating of the domestic hot water and supplemental space heating via in-slab ducts in the living room floor.

☞ Ventilation air preheating was provided with a system of earth tubes that meant to use the relatively constant ground temperature to temper incoming ventilation air.

☞ A forced-air system to collect air heated under the steel roofs was included to help offset space heating needs.

☞ The project featured three wind turbines to assess the potential contribution of wind-generated electricity to offset conventional electricity sources - one a vertical-axis turbine (that was never made operational) and two horizontal- axis wind turbines.

☞ The solar roof, solarium and domestic hot water preheat were integrated into a single system. Air was drawn with a fan under the dark metal roof whenever the air temperature under the roof was warmer than the solarium. The warm air was then passed around an uninsulated water preheat tank located under a window seat in the solarium. From there, the air was either vented to the outdoor in the summer or through ducts in the floor slab into the living room (winter) to supplement space heating.

☞ An earth tube ventilation system was installed to provide tempered ventilation air for each of the units. It was a 300-foot length of 4 inch diameter unperforated "Big O" tubing buried in the ground. Whenever the upstairs thermostat calls for heat, the circulation fan forces air through a hot water coil and at the same time a ventilation fan draws air through the underground ventilation tubes.

Monitoring

To assess the extent to which the many features influenced the performance of the dwelling units, CMHC monitored several of the systems. The monitoring program documented energy use in all seven units. Indoor air quality was also measured with several spot tests with a focus on the performance of the earth tube system.

Natural gas and electrical meter readings were collected monthly for all units. Monitoring was carried out from February 2005 to March 2006.

Outside temperature, outside relative humidity, horizontal solar gains, wind direction and speed, and rainfall during the monitoring period were measured. As well, interior temperature and relative humidity, ground-tube ventilation temperature and relative humidity output to house were also measured. In addition, the occupants were surveyed with respect to their impressions of the performance of their homes.

Energy Performance

The monitoring provided important insights regarding the many features that were explored in the design and construction of the dwelling units. An energy performance rating of EnerGuide 80, comparable to R-2000 homes, was achieved.

The monitored energy consumption of the dwelling, when compared with the conventionally built unit, ranges from 97 per cent to 142 per cent. However, direct comparisons are difficult to make due to the different housing types, different operating conditions, and differences in occupancy. Indoor temperatures in the homes were significantly different – in one, occupants kept the temperature at a cool 18˚C (64°F), while in another it was a much warmer 23˚C (73°F). This highlights the difficulty in comparing the energy consumption performance of houses because of the different operating conditions.

Calibrated HOT2000 simulations were done to compare one unit with the conventional unit under similar operating conditions. Results of these simulations showed that a unit would use about 37 per cent less space heating energy and 28 per cent less water heating energy when compared to the conventional unit under similar operating conditions. The savings would amount to a total of 26,697 MJ/year for a typical family of four when compared to the conventional house. The energy savings were attributed to the better-insulated, more airtight building envelope.

Wind Energy

The need to conduct careful site surveys of wind conditions before installing wind energy systems was highlighted by the monitoring, which revealed that the wind energy source at this location was not enough to justify the installation of the wind turbines.

The horizontal-axis wind turbines produce power only if the wind speed is greater than about 3 m/s. However, winds greater than 3 m/s occurred less than 22 per cent of the time and winds greater than 7 m/s (which would allow the turbine to generate about 50 per cent of its rated electricity output), only about three per cent of the time. The vertical-axis wind turbine was never made operational.

Solar Energy System

The solar steel roof/solarium energy system did not perform as expected. The air handling system (control system set points, system configuration, manual controls, and fan) designed to collect heat from the solar roof and attached atrium did not work as expected. The occupants did not always set the system appropriately for the season, which could result in overheating in the atrium and the dwellings. It was also estimated that the energy to operate the fan taking heat from the roof and atrium would be more than the energy collected. Under some operating conditions, the fan could also pressurize the home and contribute to conditions that could cause moisture problems in the building envelope.

If the solarium exhaust vent was left open in the winter, as happened in some cases, cold air from outside cooled the water preheat tank and froze the water lines.

The solarium itself provided limited passive solar gain because the occupants kept the blinds shut and the door separating the solarium to the house shut throughout the monitoring period. The atrium provided no usable heat and the back-draft damper was found to be an annoyance to the occupants, as it opened and banged shut during windy periods.

Earth Tube

The monitoring found that the earth-tube ventilation system provided little heat and its overall contribution to providing ventilation was uncertain. The system was set up to operate only during cold periods. This offered only limited incremental benefit because during those times air leakage due to infiltration through the building envelope is increased by higher indoor-outdoor temperature differences and the additional ventilation air from the earth tubes was least needed.

Several leakage points were found around the area where the tubes come out of the slab ("Big O" tubes to metal ducts) and at the entrance to the plenum (metal ducts to plenum), which resulted in minimal airflow through the earth tubes themselves. Mould testing indicated that there could have been exposed soil in the earth tube.

The solar roof air handling system did not work as expected. It took more energy to operate the fan taking heat from the roof than was collected.

The earth-tube ventilation system provided little heat. Leaks were found in the tubes, and mould testing suggested there may be exposed soil in the tubes.

Installation/Operation/User-Friendliness

While systems were generally installed in accordance with the design drawings, a number of deficiencies were noted, including leaky ductwork, non-operational dampers and poorly integrated control systems. Many of the systems were unnecessarily complex in design, difficult for the occupants to understand and control and hard to maintain. Some worked independently of one another and sometimes at cross-purposes. The occupants did not always understand how to optimize solar heat recovery from the steel roof and solarium.

The project demonstrates both the successes and challenges of designing and constructing sustainable housing that relies on relatively complex approaches to achieving high performance. Overall, it was found that the energy efficient integrated space and water heater and the relatively efficient building envelope contributed most to the energy efficiency of the houses.

Project monitoring demonstrated the need to keep systems and equipment simple, easy to understand and easy to operate, maintain and control. It also demonstrated the need to ensure that innovations are appropriate for the climate, location and overall applications and that they can be easily designed, installed and commissioned to ensure optimal performance. Priority should be placed on the passive elements of housing design such as passive solar design and highly insulated, airtight building envelopes as opposed to complex active mechanical systems. ☼

Seabird Island Monitoring for CMHC
Monitoring Consultant: SAR Engineering Ltd.

R-2000
For information on the R-2000 Program, contact your local program office, or call 1-800-387-2000 www.R-2000.ca

Canadian Home Builders' Association

Technical Research Committee News

Homeowners' Guide to Green Renovations Booklet

CHBA has prepared a publication that renovators can use with their clients. It's consumer-oriented, and it can help to organize conversations between renovators and consumers in a rational way. It's an electronic publication, and is available as a series of customizable PDFs. Accessible from the CHBA members' web site.

National Building Code 2010 - Proposed Changes

The 2010 NBC has largely been completed. The changes have been posted for public review from until October 30, 2009. This is the time for code users to review proposed changes, and submit comments. Every comment is valuable.

Proposed changes and comment forms are available on-line at: *www.nationalcodes.ca.*

Help Wanted
Call for volunteers

There are numerous opportunities for industry participation on codes and standards committees – these can offer very rewarding opportunities for participants. Committees meet by phone conference calls, virtual (electronic) conferencing and in person. How much time is involved depends on the group and topic. Some groups have a time-limited task, some are standing committees.

Depending on the subject, this gives participants a chance to help draft codes and standards, or test the impact of changes before they are implemented.

CHBA is looking for volunteers willing to participate on committees and task forces, at the association, or as industry representatives with provincial and national organizations. If you are interested, contact Don Johnston at the CHBA national office.

Radiant Paints Are Not Insulation

Everyone is looking for better, easier ways to make homes more energy efficient, to reduce home heating costs. New insulation products are regularly being introduced with varying degrees of effectiveness. Some products are proven to do just that, but manufacturers of others make unproven, outlandish claims, but with smooth sales pitches that skirt the truth and can confuse most.

A variety of new paint products claim that they are ceramic based, water-borne, insulating coatings that reflect more than 95% of radiant energy. Claims are made that when applied correctly, they can provide significant energy savings. Some paint manufacturers compare their product to traditional insulation by stating it is comparable to R-19, "replacing the 6 to 8 inches of traditional insulation to block initial heat load." This insulation property is supposedly a result of low thermal conductivity inherent to the nanoparticles dispersed within the coating.

The website of one distributor in Fairbanks, Alaska even claims that the product can result in savings of "20% to 40% on home heating cost."

The confusion happens because some of these paints, when used on the exterior in cooling climates, under some conditions, reduce solar heat gain, thus significantly reducing cooling requirements. Unfortunately, the marketers persist in trying to expand their sales by pushing outlandish claims stating that their products can be used both on interior and exterior walls to keep heat in during winter.

Manufacturers also persist in touting testimonials for proof of performance. While a testimonial may be OK for a character reference, it is not an appropriate way to assess the technical performance of a product because the testimonial will rarely involve a rigorous technical analysis. We know that when a product is used in a building, it is rarely done in isolation, so that any performance changes could be impacted by many other, unstated factors. Sometimes, it could even be the placebo effect – much like the sugar pill that a doctor might prescribe to a hypochondriac who magically gets cured.

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.
Canadian Home Builders' Association, Suite 500, 150 Laurier Ave. West, Ottawa, Ont. K1P 5J4
Tel: (613) 230-3060
Fax: (613) 232-8214
e-mail: chba@chba.ca
www.chba.ca

A study at the Cold Climate Housing Research Center in Alaska aimed to determine whether or not paints really do provide any insulation benefits. The intent was to test the effectiveness of the paints at improving the energy efficiency of homes in a heating-dominated climate by enhancing the insulating properties of the building envelope.

Two widely available products were tested. Each was tested to determine whether it fits the definition of a radiant barrier, changes the R-value of material it coats, or reduces heating demand of an insulated assembly.

The thermal conductivity of each coating was determined using a modified version of the standard ASTM C518 test method. The test was slightly modified because the standard is not designed to determine the conductivity of very thin coatings.

The results showed that neither product had any significant impact on reducing heat transfer or heating demand.

The emittance of each coating was determined by Air-Ins, a materials testing lab in Montreal, Canada, using the ASTM C1371 standard test method. The average emittance was 0.9, which shows that neither product is a good inhibitor of infrared (long-wave) radiant heat loss. By comparison, a regular white latex paint used for comparison in these tests has an emittance of approximately 0.85 - 0.9 (ASHRAE, 2005).

To do a test that would directly show potential energy savings from the use of these coatings, insulated boxes were built to simulate typical home construction techniques. The units were tested outdoors in Fairbanks, Alaska. The findings were that there was no dramatic difference in the performance of the two units with the coatings. Neither product contributed to the R-value of the building material on which they were applied, and cannot be considered to be an insulator. This contradicts the claims by the manufactures that these coatings can provide energy savings on the order of 20 to 40%.

The bottom line is that having enough thermal insulation is especially important in cold climates where heating dominates home energy costs. There are known methods for improving the energy efficiency of homes, such as adding additional conventional insulation (fiberglass, cellulose, polystyrene boards, spray foam and others), improving the building's air tightness, upgrading windows, and installing a more efficient heating system.

Although each house has its own unique factors to consider, these methods are well established and understood. The results from tests conducted by Cold Climate Housing Research Center show that the 'radiant' paints used indoors simply do not provide extra energy efficiency in cold climates and are not effective.

These products do have US Energy Star qualifications but only for use as a roof coating, where the primary goal is to reduce solar absorption to decrease air conditioning loads. This is a consideration in southern, cooling-dominated climates. In Canada, heating is the dominant concern.

The Cold Climate Housing Research Center (CCHRC) is an industry-based, non-profit corporation created to facilitate the development, use and testing of energy-efficient, durable, healthy, and cost-effective building technologies for Alaska and the world's cold climate regions. It was conceived and developed by members of the Alaska State Home Builders Association. The CCHRC Research and Testing Facility is based at the University of Alaska Fairbanks campus. Information: *www.cchrc.org*

Emissivity

Emissivity of a material refers to its ability to release heat. It is the ratio of the energy emitted from a surface compared with the energy emitted by a perfectly black surface at the same temperature. Emissivity is expressed as a number between 0 and 1.

An emissivity of 1 means that there is perfect heat loss. Wood stoves and heaters are typically finished with black paint so they give off the maximum amount of heat.

An emissivity of 0 means the body gives off no heat. This is why hot water and steam pipes (especially in commercial and industrial buildings) are usually covered with insulation that has a white or shiny surface. When we want to keep the heat in, we use low-emissivity glass with an emissivity of 0.1 or less.

Energy Answers

Rob Dumont

Have there been any recent advances in the area of passive solar heating for residences?

Passive solar heating has been known since the time of Socrates. However, it is only slowly catching on in Canada. Improved windows have made the recent advances possible.

In the 1970s there developed two schools of thought regarding how best to reduce space-heating bills in residences using passive means. One was called the "mass and glass" school. With this approach, large south-facing windows would be used along with concrete slabs and heavy construction such as adobe. This school had a lot of proponents coming out of the south-western United States. New Mexico was a hotbed.

New Mexico has an especially favourable solar energy climate and relatively mild outdoor temperatures compared with most of Canada. A photo of the David Wright Home in Santa Fe, New Mexico, is shown in Figure 1. In Figure 2 a cross-section of the house is shown. Note the large amounts of mass in the concrete floor and gravel beneath, and in the adobe walls for the house. Note also the insulation on the outside of the thermal mass. The mass and glass approach generally worked well in the New Mexico climate.

However, when translated to other climates, the approach did not work as well. A monitoring study done in Minnesota of a number of passive solar houses in the 1980s found that the more south glass a house had, the higher the heating bill! There were two main reasons that the energy bills for the Minnesota houses with large double-glazed south windows were higher. First, Minnesota is further north and considerably more cloudy then New Mexico. And second, Minnesota is considerably colder than New Mexico.

The other passive school was known as the "light but tight" school. This approach generally did not use additional thermal mass inside the house. However, these houses did use modest south-facing window areas, high insulation levels, well-sealed construction and heat recovery ventilators (HRVs). The Saskatchewan Conservation House was an early example of this approach. A photo of the Conservation House is shown in Figure 3. In Figure 4, a cross-section through the Conservation House is shown. Note that there was no additional thermal mass in the house.

Since the 1980s, window technology has advanced considerably. We now have triple-glazed windows with low-emissivity coatings, argon gas fills, low conductivity spacer bars, and relatively high solar transmittance. For instance, it is now possible to buy high performance windows with solar heat gain factors as high as 0.59 with R-values in the R-5 range. Given that windows have improved so much in performance, it is now time to revisit a combination of "mass and glass" and "light but tight".

Typically in light, wood-frame construction one should have no more than about 6% ratio of south window area to floor area. If the south window area is greater, the house will overheat from the high solar gains, especially in the fall.

Figure 1. South exposure of the David Wright House in Santa Fe, New Mexico (Photo Credit: Design for a Limited Planet, Skurka and Naar, 1976)

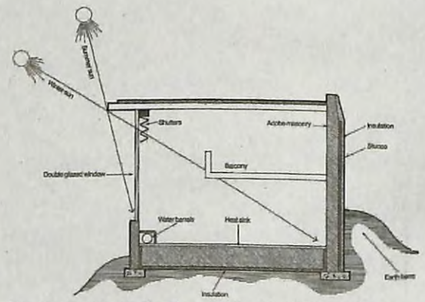


Figure 2. Cross Section of the David Wright Mass and Glass House (Credit: Design for a Limited Planet, Skurka and Naar, 1976)

Figure 3. Saskatchewan Conservation House, 1977-78 An early "light but tight" passive Canadian House. Note the modest south window area compared with the David Wright House in Santa Fe.

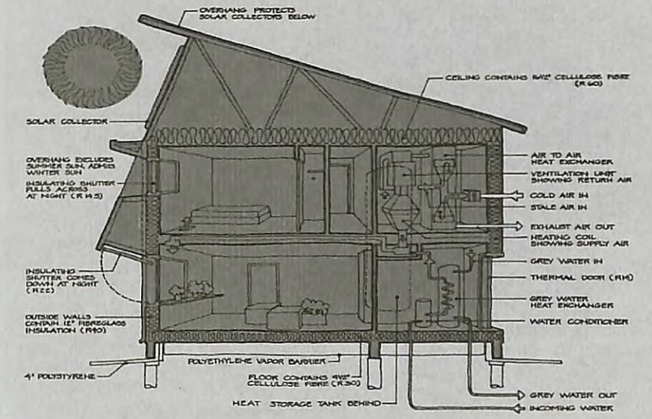

OVERHANG PROTECTS SOLAR COLLECTORS BELOW
CEILING CONTAINS 8½" CELLULOSE FIBRE (R-60)
SOLAR COLLECTOR
OVERHANG EXCLUDES SUMMER SUN ADMITS WINTER SUN
INSULATING SHUTTER ROLLS ACROSS AT NIGHT (R 14.5)
AIR TO AIR HEAT EXCHANGER
VENTILATION UNIT SHOWING RETURN AIR
COLD AIR IN
STALE AIR IN
EXHAUST AIR OUT
HEATING COIL SHOWING SUPPLY AIR
GREY WATER IN
THERMAL DOOR (R14)
INSULATED SHUTTER CLOSES OVER AT NIGHT (R22)
GREY WATER HEAT EXCHANGER
WATER CONDITIONER
OUTSIDE WALLS CONTAIN 10" FIBREGLASS INSULATION (R40)
POLYETHYLENE VAPOR BARRIER
4" POLYSTYRENE
FLOOR CONTAINS 4½" CELLULOSE FIBRE (R30)
GREY WATER OUT
INCOMING WATER
HEAT STORAGE TANK BEHIND

Figure 4. Cross Section of the Saskatchewan Conservation House. Note that no additional thermal mass was used. The heat storage tank was used for the active solar system.

Usually the worst time in Canada for a passive solar house to overheat is in late September/early October. At that time of the year the sun is lower on the horizon and more solar energy passes into the south windows. In addition it is usually still relatively warm in the early fall in southern Canada. This combination of a large solar energy input and warm outdoor temperature usually results in overheating at that time of year unless the house is carefully designed.

If, however, additional thermal mass is present in the home, the rise in temperature in the home is manageable. As a simple example, consider a home with an internal heat storage capacity of 25 megajoules per degree Celsius. This value is the value that we measured on the Saskatchewan Conservation House in Regina in 1978.

In a typical house, the interior gypsum board and the wood-framing members make up the main heat storage elements. Assume a day when the outdoor temperature is the same as indoors, as might occur in October. If 250 MJ of energy pass through the south-facing windows, the temperature in the house will rise 250/25 = 10° C. A 10°C temperature rise is outside the comfort zone for virtually everyone. This is the amount of solar energy passing through the windows in October on a sunny day at latitude 48 degrees, assuming 20 square metres (215 sq.ft.) of south glass with a solar heat gain coefficient of 0.59. If, however, the internal heat storage capacity of the house were raised to 50 MJ/°C, the rise in temperature of the house will be only 250/50 or 5°C. (This assumes that the mass is fairly thin and not, for example, in a very thick concrete slab.)

Additional thermal mass is desirable in a home as a means of storing energy between day and night and also over longer periods of time.

There are several relatively inexpensive ways of adding thermal mass to a house. In my own home this was done by placing the scrap gypsum board into the hollow interior stud cavities in the house. An architect friend carried this further by gathering scrap gypsum board from other houses and stuffing it into the hollow cavities between the floor joists in his home. This technique can be used in most homes, but one should be careful about placing too much weight on the floor joists in a home. Consult a structural engineer.

Another technique is to place a concrete topping on the wood joist floor system. A thickness of 2.5 inches of concrete will add an additional weight of about 30 pounds per square foot of floor area. On a house with 2,000 square foot of floor area, this would add 60,000 pounds of additional mass to the house. The thermal capacity of that concrete would add about 18 MJ/°C to the heat storage capacity of the house.

If the house is a slab on grade design, the concrete floor can act as a thermal mass. It is very

Figure 5. The Mill Creek Net Zero House in Edmonton, AB Mass, good glass, superinsulation, air tightness and an HRV
(Photo Credit: Mill Creek House Web Site)

important, however, to add rigid insulation underneath the entire concrete slab. Less expensive beadboard (expanded polystyrene, usually white in colour) can be used instead of extruded polystyrene (usually blue or pink). Depending on the location in Canada and soil conditions, R-values in the range of R-15 and higher should be used.

The technique of adding additional thermal mass by way of concrete toppings was recently used in a house in Edmonton. If you go to the web site for the Edmonton Mill Creek House (http://greenedmonton.ca/MillCreekNetZeroHome) there is a good description and photos of the technique that was used. The house also used high quality Duxton fibreglass windows with a good solar heat gain factor and high R-values.

A picture of the Mill Creek house is shown in figure 5. As can be seen, the south side has a lot of glazing. To save money, the 2.5 inch thick concrete topping also serves as the finish floor for the house. A staining technique was used to enhance the appearance of the concrete floor. If the house did not have this additional thermal mass, it would be very prone to overheating because of the large south window area. The house is very well insulated with R-100 attic insulation, R-56 walls, R-25 basement floor, airtight construction and a heat recovery ventilator. The house also has a photovoltaic system and a solar domestic hot water heater. The house will be occupied shortly.

The "mass and good glass" approach will work best in the sunnier parts of Canada. However, in Canada we do have some notoriously cloudy locations such as Prince Rupert on BC's north coast where the approach might not work well.

A computer model such as HOT-2000 can help greatly with analyzing where the passive solar approaches will work best. Great south windows with a high solar heat gain factor and high R-values are crucial in the Canadian climate to make a great passive solar design. The "boring" parts like superinsulation, air tightness, and a good HRV are also crucial.☼

House Fires: Running out of Time

Scientists at the National Research Council's Fire Research Program study house fire evacuation times. They compare the time occupants need with the time available before heat, smoke and toxic gases incapacitate them.

Fire researchers ran full-size experimental house fires which started in the basement and threatened the first floor escape route. If these fires had happened in a real house at night, the family sleeping upstairs might have been hopelessly trapped.

Effects of floor construction on spread of heat and gases

NRC has a full-scale, two-storey plus basement 'test house' apparatus. Dr. Joseph Su used it to investigate the structural integrity in fire of seven unprotected engineered wood floor assemblies and a solid wood joist floor. Under each floor assembly in turn, a standardized upholstery fire was set in the test house 'basement', and allowed to burn. In each test, the time to structural failure of the floor assembly was noted, as well as the temperature rise, and the smoke and toxic gases detected in the upper storeys. The data was used to calculate the time before adults in the upper storeys would likely be incapacitated.

Assemblies tested included wood I joist, steel C joist, metal-plate wood truss, metal web wood truss and solid wood joists. Each assembly had a single layer of oriented strandboard 'subfloor', which was loaded with concrete blocks to 0.95kPa (20 pounds/square foot), and was left unprotected below. This resembles a basement with an unfinished ceiling. The solid wood joist floor assembly rated best, giving the longest times for which the upper storeys were tenable. It was also found that keeping the basement door closed more than doubled these times. In all cases the heat and the products of combustion would have killed the occupants before the structural failure of the tested floor assembly.

In the test fires, the estimated available escape time for healthy adults on the first and second storeys above the fire was as little as 3 minutes, with dense smoke causing problems much sooner. The solid wood joist floor assembly with the basement door closed provided 8 minutes escape time. People in a second floor bedroom with its door closed would have had a little more time to escape, but not through the untenable first floor.

People in fire emergencies

Senior Researcher Dr. Guylene Proulx studies human behaviour in fire situations. She finds common features in Canadians' reports of their own behaviour during night-time fire emergencies (which cause the most loss of life), in tests of their responses to fire alarms, and in fire drill results.

Dr. Proulx reports that many people fail to respond to the fire alarm signal from a smoke detector because they do not hear it, or do not recognize it. Others mistake the alarm signal for some unimportant sound. That is why there is a move to change the characteristic sound generated by smoke detectors, from a loud sound with a single frequency to a modulating frequency noise with variation in sound levels.

Those who are deeply asleep are often not roused by an alarm signal. Individuals have widely varying sleep patterns, but children and teenagers, those who drink alcohol and those who take sleeping pills have periods of very deep sleep.

Of those occupants who do respond to the alarm signal, some will investigate to confirm the fire before deciding to leave, and perhaps stay to fight it. Those who flee often have a choice of routes to safety, and that decision takes time. Many stay to warn others and may even gather their family and valuables together before escaping. In winter, most Canadians will put on warm clothes and footwear while still inside. Dr. Proulx calls this 'pre-movement time', and it can be as much as 10 minutes. This does not include those who go back into the burning house.

Dr. Proulx estimates the total escape time required as from 2 to 16 minutes, including time for the smoke detector to activate and for travel to safety. In Dr. Su's fire tests, there were only 3 to 8 minutes available for escape.

Fire test assembly results

Test number	GWB screws 10 mm from edges	GWB screws 38 mm from edges on Resilient Channels	Load 75% of max	Load 100%	Insulation	Fire Resistance minutes
One Layer of Gypsum Wall Board						
1	X		x		none	30 mins
2		x	x		none	45 mins
5		x	x		Glass Fibre	36 mins
6		x	x		Mineral wool	60 mins
7		x	x		Cellulose	59 mins
22		x		x	None	40 mins
Two Layers of Gypsum Wall Board						
3	x		x		None	51 mins
4		x	x		None	80 mins
8		x	x		Glass Fibre	67 mins
9		x	x		Mineral wool	72 mins
10		x	x		Cellulose	74 mins

How can the chances of surviving a fire unharmed be improved?

Take the familiar precautions and Code requirements seriously, in our own homes and in our design and construction work.

- Use plenty of interconnected hardwired smoke alarms, at least one per floor as in the Code for new homes. Every interconnected device sounds the alarm when any device detects fire, improving the chances of all occupants hearing an alarm.
- Consider installing fire sprinklers.
- Make bedroom windows viable escape routes. Because elderly people seldom use windows to escape fire, make their windows obviously accessible -- and take every other opportunity to make their housing safer.
- Provide a clear path to safety away from cooking equipment.
- Build in features to help people navigate through their smoke-filled home.

As Flannery O'Connor wrote: The Life You Save May Be Your Own.

Major Causes of Fatal House Fires:

- ❒ Cigarettes and pipes. Lit material discarded into upholstery or bedding can smolder until occupants are asleep, or start a fast flaming fire.
- ❒ Candles, especially in bedrooms where they ignite beds.
- ❒ Cooking, most often burning cooking oil.
- ❒ Heating equipment, mainly fireplaces and chimneys.

References: available in pdf at www.nrc-cnrc.gc.ca

1. Fire Performance of Houses, Phase 1 Study of Unprotected Floor Assemblies in Basement Fire Scenarios. NRC IRC-RR- 252. Su, J.Z., Benichou, N., Bwalya, A.C., Lougheed, G.D., Taber, B.C., Leroux, P., Proulx, G., Kashef, A., McCartney, C., Thomas, J.R. 2008.
2. Evacuation from a Single Family House. NRCC-51385. G. Proulx. 2009.
3. Egress Times from Single Family Houses. NRC IRC-RR-209. G. Proulx, N.R. Cavan and R. Tonikian. 2006.

NRC·CNRC

Hybrid hydrogen / natural gas high-efficiency furnace system

By John Burrows

Hydrogen is seen as an energy carrier of the future and significant research on its generation, storage and utilization is underway. Prior to widespread use of hydrogen energy, it is a logical transition for hydrogen to be blended with conventional fuels such as natural gas, oil or diesel for combustion through conventional means.

To advance knowledge in this area, Natural Resources Canada, in collaboration with the Canadian Centre for Housing Technology (CCHT),[1] assessed the performance of a hybrid hydrogen generator / gas-fired furnace in a residential application using CCHTs twin house facility.

Test arrangement

Before the field trial, the hybrid system was investigated in an NRCan laboratory with a range of hydrogen/natural gas mixtures. The optimized system was then installed at the CCHT research house (Figure 1). The energy performance of the hybrid system was compared to the energy performance of an identical high-efficiency furnace in the reference house next door.

The assessed system consisted of a Hmax-Cell™C5 electrolyzer and an Olsen (GTH-50) high-efficiency condensing natural gas furnace integrated with check valves, pipes and flame arrester. The system allowed the two fuels to meet at a mixing section before entering the furnace.

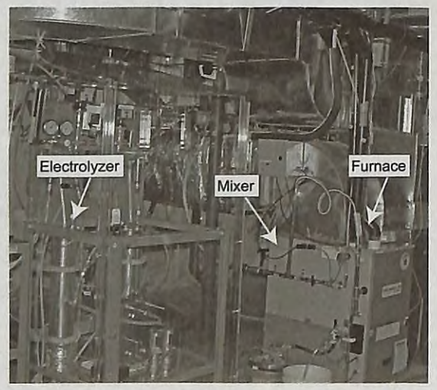


Figure 1. Hybrid system arrangement

The electrolyzer was capable of providing 1.8 litres per minute of hydrogen continuously and up to approximately 2.4 litres per minute for up to 20 minutes. Natural gas was supplied from the regular residential gas line fitted with a ball shut-off valve and a check valve to prevent any possible back-flow of hydrogen. The hydrogen supply to the furnace had an electrically operated solenoid valve, a check valve and a flame arrester. It then met the natural gas supply in a "T" junction containing a metal helix to promote better natural mixing of the two gases. The natural gas/hydrogen blend then entered the furnace combustion system in conventional fashion.

The valve that controlled the hydrogen supply to the furnace was controlled by a logic circuit. When all required conditions were met, the hydrogen valve was opened. The hydrogen was admitted to the fuel line shortly after the furnace start-up process was complete, and turned off immediately as the shutdown process began.

Results

The calculated efficiency of the reference house furnace was 92.7% while burning natural gas and 93.2% when burning blended 7%$_{vol}$ hydrogen and natural gas fuel, a slight increase of 0.5% efficiency.

The added electrical consumption due to the electrolyzer ranged from 2.12 to 5.12 kWh/day, with an average of 3.37. The average decrease in natural gas consumption was 11.0 MJ/day over the testing period.

Performance data were used to calculate the energy consumption of the hybrid system over a full range of average outdoor temperatures. At low heating loads, the savings in gas consumption were offset almost exactly by the increased electrical consumption of the electrolyzer. However, at high heating demands, the hybrid energy system set-up required more energy than the benchmark (natural gas only). The net increase was highest on the coldest day of the analysis

John Burrows is an engineer and technical writer.

CCHT is a partnership between the National Research Council of Canada, Natural Resources Canada, and Canada Mortgage and Housing Corporation.

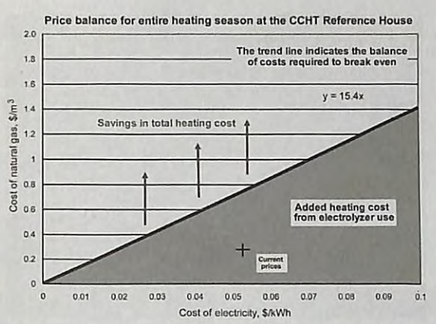


Figure 2. *Cost analysis for the operation of the electrolyzer during a typical Ottawa heating season*

–25°C – when the electrolyzer would be expected to cause the reference house heating system to consume an additional 22 MJ/day.

The hybrid system performance data were projected over climate conditions for the entire 2002-2003 heating season in Ottawa and it was calculated that an additional 1132 kWh of electricity would be required to produce 2753 MJ of gas savings. At 2002-2003 gas and electrical prices, the added seasonal cost of operating the system was $30.86.

In order for the electrolyzer running in the test configuration to provide an operating profit during the heating season, the cost of gas (in $/m³) must be greater than 15.4 times the price of electricity (in $/kWh) as illustrated in Figure 2.

Conclusions

This experiment showed that a hybrid furnace-electrolyzer energy system can be successfully used in residential applications. Up to 25% of natural gas can be replaced by hydrogen without a need for significant modification of the heating appliances. Hydrogen was produced using grid electricity to power an electrolyzer. The hydrogen replaced 9% of the natural gas required to heat the research house and resulted in a 0.5% increase in furnace efficiency.

Based on the prices of electricity and natural gas at the time of the experiment, the cost of heating using a blend of hydrogen and natural gas was higher during low temperatures – $30.86 higher for the 2002-2003 heating season in Ottawa.

The hybrid system becomes more economical with lower electricity rates and higher natural gas prices. The economy of the hybrid heating system could be improved by using off-peak grid electricity or solar/wind electricity to produce hydrogen and store it for use during other parts of the day whenever there is a demand for heat. ☼

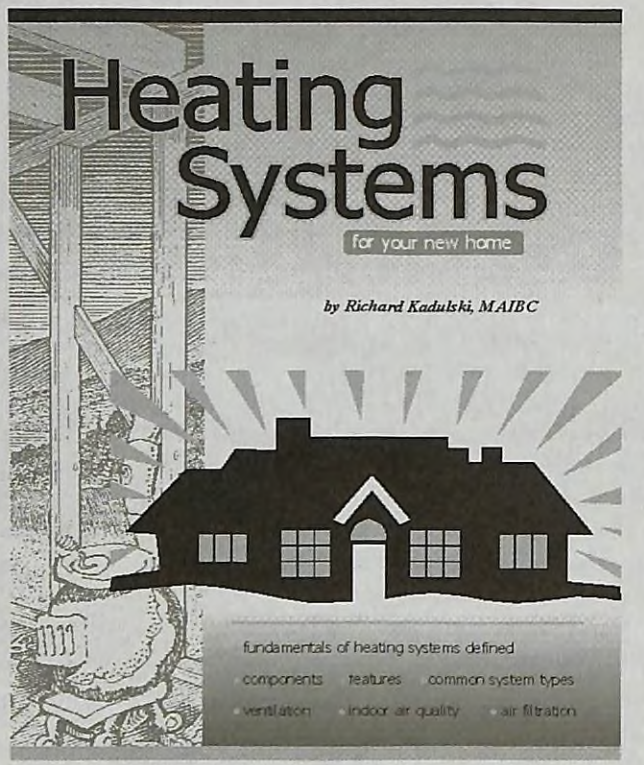
*The **speedi-sleeve**® - a fitting solution for 4"Ø HRV Ceiling Grilles and Diffusers and 2"Ø Hi-Velocity Diffusers*

speedi-sleeve®

*... available sealed to a **4/5 increaser** for connecting to 5"Ø duct*

*... for retrofit applications, try adding a **clamping ring***

ENEREADY PRODUCTS LTD.
#4 - 6420 Beresford Street • Burnaby • British Columbia CANADA • V5E 1B6
Telephone: 604-433-5697 • Fax: 604-438-8906 • www.enereadyproducts.com


Heating Systems
for your new home
by Richard Kadulski, MAIBC
fundamentals of heating systems defined
components features common system types
ventilation indoor air quality air filtration

$19.95 Mail order: $ 23.79 ($19.95 + plus $ 2.50 shipping & handling + GST)

Available Now!

Heating Systems
for your new home
by Richard Kadulski, MAIBC

Heating Systems for Your New Home is the book that explains heating system options for your new home.

Contents include:

- **Heating Fundamentals**
- **Heating System Types**
- **Features to consider**
- **Common system types described**
- **Overview of ventilation**
- **Filtration**
- And much more!

the drawing-room graphic services ltd.
Box 86627 North Vancouver, B.C. V7L 4L2
FAX (604) 689-1841
e-mail: solplan@shaw.ca

SOLPLAN REVIEW is an independent Canadian Journal published 6 times per year to serve the needs of professionals and interested lay persons. It provides news, technical details, new product information, insights and commentary on developments covering all aspects of building science and energy efficient building practice for new and retrofit residential construction. Technical information is presented in a clear, concise manner without resorting to jargon.

SOLPLAN REVIEW is an independent subscription supported publication that relies on the support of readers. If you are seeing this journal for the first time, and find it valuable, why not ensure that you don't miss any copies. Subscribe today!

YES, I WANT TO SUBSCRIBE TO SOLPLAN REVIEW

In Canada: 1 year: $52.50 ($50.00 + 2.50) [NB, NS, NL $56.50 includes HST]
2 years: $93.97 ($89.50 + 4.47) [NB, NS, NL $101.13 includes HST]
USA and other foreign: 1 year $57.00 per year, 2 years $103.50 (USA and other foreign in US funds).
Pay by: VISA ☐ MASTERCARD ☐ AMERICAN EXPRESS ☐ CHEQUE/CHECK ☐

Card No _____ Exp date _____

Signature _____

NAME _____

ADDRESS _____

_____

POST CODE _____

the drawing-room graphis services ltd.
PO Box 86627 North Vancouver, BC V7L 4L2
Fax: 604-689-1841
e-mail: solplan@shaw.ca

GST registration: R105208805